Title Page

Report Title: Carbon Sequestration in Reclaimed Mined Soils of Ohio

Type of Report: Progress Report for 5th Quarter

Reporting Period Start Date: 1 October 2004

Reporting Period End Date: 31 December 2004

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Date Report was issued: Month [January] Year [2005]

DOE Award No: DE-FC26-03NT41903

Name and Address of Submitting Organization: The Ohio State University, Research Foundation, 1960 Kenny Road, Columbus, OH 43210-1063

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ABSTRACT

Assessment of soil organic carbon (SOC) sequestration potential of reclaimed minesoils (RMS) is important for preserving environmental quality and increasing agronomic yields. The experimental sites were characterized by distinct age chronosequences of reclaimed minesoil and were located in Guernsey, Morgan, Noble, and Muskingum Counties of Ohio. These sites are owned and maintained by Americal Electrical Power. These sites were reclaimed (1) with topsoil application, and (2) without topsoil application, and were under continuous grass or forest cover. In this report results are presented from the sites reclaimed without topsoil application between 1956 and 1969. Three sites are under continuous grass cover and the three under forest cover since reclamation. Three core and three bulk soil samples were collected from each site from three slope positions (upper; middle, and lower) for 0-15 cm and 15-30 cm depths, and texture, pH and electrical conductivity (EC), soil bulk density (ρ_b), SOC, total nitrogen (TN) stocks were determined. No differences in sand and clay contents, bulk density, SOC and TN stocks were observed within different slope positions within each site. However, sand [R56-G (17.1%) < R69-G (29.1%) = R62-G (29.1%)], and silt [R56-G (58.3%) > R69-G (47.7%)] contents, bulk density [R62-G (1.25 Mg ha^{-1}) > R69-G (0.94 Mg ha^{-1}) = R62-G (0.90 Mg ha^{-1})] varied significantly on the upper slope position among sites under continuous grass cover. Smaller but significant differences were also observed for pH [R69-G (8.3) > R56-G (7.7) = R62-G (7.9)] and EC [R56-G (0.66 dS m^{-1}) > R62-G (0.25 dS m^{-1}) = R69-G (0.24 dS m^{-1})] on upper slope positions among sites under grass.

Comparing all sites stochastically, sand and clay contents were similar among all sites except R62-F for both depths. Similarly, soil bulk density was also similar among all sites except R62-G

for both depths. There were few differences in total nitrogen and soil organic C stocks among different sites with R56-F having the highest TN (4.3 Mg ha^{-1}) and SOC (70.7 Mg ha^{-1}) stock and R62-F the lowest (1.1 and 28.0 Mg ha^{-1}, respectively). The lowest TN and SOC stocks were mainly due to the sandy nature of soil. However, possibility of coal contamination cannot be totally ruled out in SOC stocks stock from R56-F. The increases in SOC are important for improving soil and environment quality, and soil productivity. No significant differences in SOC among most sites also indicate that these sites reclaimed without topsoil application have reached the equilibrium.

Table of Content

1.0 **Executive Summary**

This research project is aimed at assessing the soil organic carbon (SOC) sequestration potential of reclaimed minesoils (RMS) and is supported by US Department of Energy- National Energy Technology Laboratory. The proposed research focuses on: (1) assessing the sink capacity of RMS to sequester SOC in selective age chronosequences, (2) determining the rate of SOC sequestration, and it's spatial (vertical as well as horizontal) and temporal variation, (3) developing and validating models for SOC sequestration rate, (4) identifying the mechanisms of SOC sequestration in RMS, (5) evaluating the potential of different methods of soil reclamation on SOC sequestration rate, soil development, and changes in soil mechanical and water transmission properties, and (6) establishing the relation between SOC sequestration rate, and soil quality in relation to soil structure and hydrological properties.

Before 1972, surface mining operations were performed by removing the soil and underlying strata and piling them on a side. After mining operations were complete, due to the nonexistence of any specific reclamation guidelines, the excavated area was planted to trees or grass without grading or reclamation. After 1972, Ohio Mineland Reclamation Act (also 1977 SMRCA) made it mandatory to grade the area back to it's original topography and reclaim it with topsoil application. In this project, several experimental sites were identified, which were reclaimed both prior to SMRCA regulation (without topsoil under grass or forest) and after (with topsoil under grass or fores). All these sites are characterized by distinct age chronosequences of reclaimed minesoil, and sites are located in Guernsey, Morgan, Noble, and Muskingum Counties of Ohio, and are maintained and owned by American Electrical Power.

A total of six sites were identified for the preliminary investigation that were reclaimed with topsoil application, out of which three are under forest and three under continuous grass cover. Three sites were identified in reclaimed soil without topsoil application, out of which one was under forest and two under grass cover. In addition, two unmined sites, one each under forest and grass cover, are also identified. The unmined sites and those reclaimed after 1972 with topsoil application have gentle or regular slope gradients and are easily accessible. The sites reclaimed before 1972 without topsoil application under forest have steep and abrupt slope and are not easily accessible.

Soil samples were collected during December 2003 to August 2004 from 0-15 cm and 15-30 cm depths. This report presents the data from six sites reclaimed without topsoil application. Three sites under continuous grass were reclaimed in 1956 (R56-G), 1962 (R62-G), and 1969 (R69-G), and the remaining three sites are under continuous forest and were reclaimed in 1956 (R56-F), 1962 (R62-F), and 1969 (R69-F). All these sites had high slope gradients; therefore, soil sampling was carried out on upper, middle and lower slope positions. Three core and three bulk soil samples were collected from each of the experimental site from each slope position for 0-15 and 15-30 cm depths. The soil properties determined include: soil bulk density (ρ_b), texture, pH, electrical conductivity (EC), SOC, total nitrogen (TN) stocks.

No differences in sand and clay contents, bulk density, SOC and TN stocks were observed within different slope positions for each site. However, sand [R56-G (17.1%) < R69-G (29.1%) = R62-

G (29.1%)], and silt [R56-G (58.3%) > R69-G (47.7%)] contents, bulk density [R62-G (1.25 Mg ha^{-1}) > R69-G (0.94 Mg ha^{-1}) = R62-G (0.90 Mg ha^{-1})] varied significantly on the upper slope position among sites under continuous grass cover. Smaller but significant differences were also observed for pH [R69-G (8.3) > R56-G (7.7) = R62-G (7.9)] and EC [R56-G (0.66 dS m^{-1}) > R62-G (0.25 dS m^{-1}) = R69-G (0.24 dS m^{-1})] on upper slope positions among sites under grass.

Comparing all sites stochastically, sand and clay contents were similar among all sites except R62-F for both depths. Similarly, soil bulk density was also similar among all sites except R62-G for both depths. There were few differences in total nitrogen and soil organic C stocks among different sites with R56-F having the highest TN (4.3 Mg ha^{-1}) and SOC (70.7 Mg ha^{-1}) stock and R62-F the lowest (1.1 and 28.0 Mg ha^{-1}, respectively). The increases in SOC are important for improving soil and environment quality, and soil productivity. The lowest TN and SOC stocks in R62-F were mainly due to the high sand content of soil. However, possibility of coal contamination in SOC stocks stock from R56-F cannot be totally ruled out. No significant differences in SOC among most sites also indicate that these sites reclaimed without topsoil application have reached the equilibrium.

2.0 Experimental

2.1 Experimental Sites:

The experimental sites identified were: (1) reclaimed prior to the 1972 Ohio Mineland Reclamation Act or the 1977 surface mining reclamation and control act (SMRCA), under continuous grass and forest and without topsoil application, and (2) reclaimed after the 1972 Ohio Mineland Reclamation act, which made application of topsoil mandatory for reclamation, under continuous grass and forest. These sites are maintained by the American Electric Power (AEP) Co., and are located along the borders of Guernsey, Morgan, Noble, and Muskingum Counties of Ohio (Fig. 1). This report includes the analysis of soil data from: (i) six sites reclaimed without topsoil application, three of them under continuous forest and three under continuous grass cover. All these sites were hilly and therefore, three soil samples were collected from each slope position (upper, middle and lower) in each site and depth.

2.2 Collection of Soil Sample

Three samples were collected using 6 cm long and 6 cm diameter stainless steel cores from each of the experimental sites reclaimed in 1956 (R56-G; R56-F), 1962 (R62-G; R62-F) and 1969 (R69-G; R69-F) from 0-15 and 15-30 cm depths for three slope positions. Bulk soil samples were also collected from each of the site for both depths and slope positions using a push probe.

2.3 Analysis of Soil Samples

2.3.1 **Soil Bulk Density**

All soil cores collected in the field were brought to the lab and trimmed at both ends and bulk density (ρ_b) was assessed according to the method described by Blake and Hartge (1986).

2.3.2 **Particle Size Distribution**

All soil samples from both depths were air-dried and clods were broken using rolling wooden pins and passed through 2-mm sieve. About 50 g of soil was used for the determination of particle size distribution by the hydrometer method (Gee and Bauder, 1986).

2.3.4**. Soil Organic Carbon Concentration and Stocks**

The air-dried soil was ground to pass through 0.25 mm sieve. About 1 g of the soil was used for the determination of total carbon (TC) and total nitrogen (TN) concentrations by the dry combustion method (Elementar, GmbH, Hanau, Germany). The SOC and TN stocks were calculated as the product of SOC or TN concentration, ρ_b and the specific depth of soil layer.

2.3.5 **Soil pH and Electrical Conductivity**

The electrical conductivity (EC) and pH were measured on soil pastes (1:1 in soil:water suspension) using a hand held conductivity meter and pH electrode (Mclean, 1982; Rhoades, 1982).

2.4. Statistical Analysis

The analysis of variance (ANOVA) was computed for slope position x sample, and site x sample interactions using Statistical Analysis System (SAS Institute, 1989) separately for soils reclaimed with topsoil application and without it for each depth. Significant mean interactions and the least significant differences (LSD) for mean separation were calculated using Bonferroni multiple comparison method separately for each depth for $P \leq 0.05$.

3.0 Results and Discussion

3.1 **Interactions among slope positions for each site separately**

In R62-G, no significant differences were observed among different slope positions for sand, silt and clay contents, bulk density, SOC, and EC for both depths (Tables 1-3). The TN stocks were in general low and significantly different among three slope positions with upper (2.7 Mg ha^{-1}) > middle (1.1 Mg ha^{-1}) = lower (0.8 Mg ha^{-1}) for 0-15 cm depth only. Soil EC was higher for lower (0.31 dS m^{-1}) than upper (0.0.25 dS m^{-1}) and middle (0.26 dS m^{-1}) slope positions for 0-15 cm depth only. In R69-G, significant differences were observed for sand content [upper (32.4%) = lower (31.7%) > middle (25.7%)], silt content [middle (53.0%) > upper (47.7%)] and TN stocks [lower (4.2 Mg ha^{-1}) > middle (2.3 Mg ha^{-1})] for 0-15 cm depth only (Tables 1-3).

In R56-F, TN [upper(4.3 Mg ha^{-1}) > lower (1.7 Mg ha^{-1}) and SOC stocks [upper (70.7 Mg ha^{-1}) > lower (41.4 Mg ha^{-1}) were significant for 0-15 cm depth and sand {upper (28.3%) > lower (19.8%), silt [lower (60.3%) > upper (52.7%)] and clay [middle (22.2%) > upper (19.0%)] contents for 15-30 cm depth. In R62-F, significant differences were observed for SOC [upper (31.1 Mg ha^{-1}) > middle (13.6 Mg ha^{-1}) = lower (10.1 Mg ha^{-1})], and pH [for 15-30 cm depth. In R69-F significant differences were observed in SOC stock [lower (60.7 Mg ha^{-1}) > upper (31.9 Mg ha^{-1})] only for 15-30 cm depth.

3.2 **Interactions among different sites under grass cover at various slope positions**

At the upper slope position, significant differences were observed for sand [R56-G (17.1%) < R69-G (29.1%) = R62-G (29.1%)], silt [R56-G (58.3%) > R69-G (47.7%)] and clay [R56-G

(24.7) > R69 (17.3) = R62-G (17.3%)] contents, and ρ_b [R62-G (1.25 Mg ha^{-1}) > R69-G (0.94 Mg ha^{-1}) = R62-G (0.90 Mg ha^{-1})], pH [R69-G (8.3) > R56-G (7.7) = R62-G (7.9)], and EC [R56-G (0.66 dS m^{-1}) > R62-G (0.25 dS m^{-1}) = R69-G (0.24 dS m^{-1})] in the 0-15 cm depth. Significant differences were also observed for sand [R69-G (32.4%) > R56-G (17.1%)] and silt [R56-G (58.3%) > R69-G (47.7%)] contents and bulk density [R62-G (1.29 Mg m^{-3}) > R56-G (1.15 Mg m^{-3})] for 15-30 cm depth (Tables 1-3).

At the middle slope position, differences were observed in silt content [R62-G (55.3%) > R69-G (53.0%) only for 0-15 cm depth. In the lower slope position, silt content [R62-G (53.3%) > R69-G (50.3%)], bulk density [R62-F (1.20 Mg m^{-3}) > R69-G (0.97 Mg m^{-3})], TN stock [R62-G (0.8 Mg ha^{-1}) < R69-G (4.2 Mg m^{-3})] were significantly different for 0-15 cm depth.

3.3 **Interactions among different sites under forest cover at various slope positions**

At the upper slope position, significant differences were observed for sand [R62-F (63.2%) > R56-F (25.7%) = R69-F (23.1%)] and silt [R62-F (23.3%) < R56-F (53.3%) = R69-F (57.0%)] contents, TN stocks [F56-F (4.3 Mg ha^{-1}) > R62-F (1.1 Mg ha^{-1})] and EC [F56-F (0.45 dS m^{-1}) > R62-F (0.15 dS m^{-1})] for 0-15 cm depth. Only SOC stock [F56-F (437.9 Mg ha^{-1}) > R62-F (31.1 Mg ha^{-1})] and pH [R62-F (8.4) > R56-F (8.1)] were significantly different for 15-30 cm depth.

At the middle slope position, sand and silt contents, TN and SOC stocks, pH and EC were significant for both depths, and clay content and bulk density for 15-30 cm depth only. The sand content was lowest for R56-F for both depths (19.5 and 20.8%, respectively), SOC stock for R56-F (18 and 13.6 Mg ha^{-1}, respectively), and pH for R56-F (7.9, 8.1, respectively).

At the lower slope position, significant differences were observed for sand and silt contents for both depths; clay content and EC for 0-15 cm, and bulk density and SOC for 15-30 cm depth. Sand content was lowest for R56-F for both depths (23.1 and 19.8%, respectively), silt for R62-F (29.7 and 34.3%, respectively), and SOC stock for FD62-F (10.1 Mg ha^{-1} for 0-15 cm depth).

3.4 **Stochastic interactions among six sites at various slope positions**

At the upper slope position overall, sand content was the highest in R29-F (63.2%), silt in R56-G (58.3%) and R69-F (57.0%), clay in R56-G (24.5%), TN and SOC stocks in R56-F (4.3 and 70.7 Mg ha^{-1}, respectively), and bulk density in R62-G (1.25 Mg m^{-3}) for 0-15 cm depth. For 15-30 cm depth, TN stock and bulk density were highest for R62-G (2.4 Mg ha^{-1}; 1.29 Mg m^{-3}, respectively) (Tables 1-4).

At the middle slope position for 0-15 cm depth, sand content (51.8%) was highest and silt (33.0%) and clay (13.5%) contents lowest for R62-F. The TN and SOC stocks were highest for R56-F (4.3 and 7.7 Mg ha^{-1}). The R56-F is the oldest reclaimed site and is under continuous forest cover, which is consistent with higher TN and SOC stocks for this site. Bulk density is highest for R65-G (1.25 Mg m^{-3}). For 15-30 cm depth, sand content was lowest (28.3%) and silt content highest (19%) for R56-F. The TN (2.8 Mg ha^{-1}) and SOC (61.5 Mg ha^{-1}) stocks were highest for R62-G. The higher TN and SOC stocks in R62-G were probably due to the deeper grass roots and higher soil bulk density.

At the lower slope position for 0-15 cm depth, silt and clay contents were highest for R56-F. This was consistent with higher silt and clay contents in the middle slope for this site. R56-F had a very high slope and, therefore, silt and clay particles are transported due to water erosion. Soil bulk density (1.31 Mg m^{-3}) was again the highest for R62-G. Overall soil bulk density was highest for R62-G for both depths. This site was managed for last several years and was used as a grazing land for 5 to 7 years in past. The compaction associated with animal traffic and the machineries for managing the site may have increased the soil bulk density. The bulk density was lower than one for all other sites for 0-15 cm depth. Soil pH for all sites and depths was > 7 and EC < 4 dS m^{-1} and was favorable for vegetation growth. Low EC further improved soil structure and increased root development and grass growth.

3.5 **Soil organic carbon stocks**

In general with the exception of R62-F, SOC stocks were higher in sites under continuous forest cover than under continuous grass cover for all three slope positions. Some significant differences were observed among different sites, with SOC stocks were highest for R56-F (70.7 Mg ha^{-1}) for upper slope position and for middle and bottom slope positions SOC stocks were highest from R69-F (79.8 and 63.6 Mg ha^{-1}, respectively). However, coal contamination cannot be totally ruled out from the SOC stocks reported for these sites. No significant differences among most sites probably indicate that these sites reclaimed without topsoil application have reached the equilibrium.

4.0 **Conclusion**

Sand and clay contents were similar among all sites except R62-F for both depths. Similarly, soil bulk density was also similar among all sites except R62-G for both depths. There were few differences in total nitrogen and soil organic C stocks among different sites with R56-F having the highest TN and SOC stock and R62-F the lowest. The lowest TN and SOC stocks were mainly due to the sandy nature of soil. However, possibility of coal contamination cannot be totally ruled out in SOC stocks stock from R56-F. The increases in SOC are important for improving soil and environment quality, and soil productivity. No significant differences in SOC among most sites also indicate that these sites reclaimed without topsoil application have reached the equilibrium.

5.0 **Tasks to be performed in the next Quarter (January- March 2005)**

We will continue to perform laboratory analysis on determining:

1. water stable aggregatation
2. soil organic carbon in macro and microaggregate fractions
3. coal C content in soils reclaimed without topsoil application, and
4. statistical analysis of data on soil physical and chemical properties.

6.0 **References**

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(A) R56-G

(B) R69-G

(C) R56-F

(D) R69-F

Fig. 1. Map of the experimental sites reclaimed without topsoil application (A) in 1956 under grass cover (R56-G), (B) in 1969 under grass cover (R69-G), (C) in 1956 under forest cover (R56-F), and (D) in 1969 under forest cover (R69-F)

Table 1. Mean and standard deviations (SD) of sand, silt and clay contents at different slope positions (U-upper, M is middle, and L is lower slope)

	Sand %						Silt %						Clay %					
Sites	U		M		L		U		M		L		U		M		L	
	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
									0-15 cm									
R56-G	17.1	0.0					58.3	1.2					24.5	1.2				
R62-G	29.1	4.2	25.7	1.2	29.1	1.2	53.7	3.8	55.3	0.6	53.3	0.6	17.3	0.6	18.9	0.6	17.6	1.0
R69-G	32.4	2.0	27.7	3.1	31.7	1.2	47.7	4.2	53.0	1.0	50.3	0.6	19.9	2.3	19.3	2.9	17.9	0.6
R56-F	25.7	8.7	19.5	4.3	23.1	2.0	53.3	6.7	57.7	2.1	56.7	1.2	21.0	2.5	22.8	2.3	20.2	1.2
R62-F	63.2	9.2	51.8	21.6	58.5	13.0	23.3	5.9	33.0	14.2	29.7	9.1	13.5	7.1	15.2	7.5	11.8	4.0
R69-F	23.1	3.5	30.5	4.2	30.5	11.5	57.0	2.6	51.0	4.6	52.0	7.9	19.9	1.0	18.5	0.6	17.5	4.0
									15-30 cm									
R56-G	22.5	6.1					56.3	6.7					21.2	0.6				
R62-G	25.7	1.2	24.4	3.5	29.7	4.2	56.3	0.6	56.7	2.5	54.3	2.1	17.9	1.5	18.9	1.5	15.9	2.1
R69-G	35.1	8.1	38.4	14.4	33.7	4.2	47.7	4.0	44.7	8.3	47.7	4.9	17.3	4.0	16.9	6.1	18.6	1.7
R56-F	28.3	6.4	20.8	2.5	19.8	1.2	52.7	5.5	57.0	1.7	60.3	1.2	19.0	2.1	22.2	0.8	19.9	0.0
R62-F	35.8	11.1	40.5	8.1	50.5	12.7	45.7	7.5	42.7	4.5	34.3	7.6	18.5	4.0	16.8	3.8	15.2	5.3
R69-F	29.8	8.3	26.5	4.2	27.1	11.1	51.7	8.5	56.0	2.0	55.3	10.0	18.5	0.6	17.5	2.3	17.5	2.1

R56-G is site reclaimed in 1956 under grass cover, R62-G- reclaimed in 1962 under grass cover, R69-G- reclaimed in 1969 under grass cover, R56-F reclaimed in 1956 under forest cover, R62-F reclaimed in 1962 under forest cover, and R69-F- reclaimed in 1969 under forest cover

Table 2. Mean and standard deviations of bulk density, total nitrogen and soil organic C stocks at different slope positions (U-upper, M is middle, and L is lower slope)

Sites	Bulk density (Mg/m^3)						TN stock (Mg/ha)						SOC stock (Mg/ha)					
	U		M		L		U		M		L		U		M		L	
	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
0-15 cm																		
R56-G	0.90	0.03					3.2	0.5					52.3	4.8				
R62-G	1.25	0.04	1.17	0.08	1.20	0.10	2.7	1.0	1.1	0.3	0.8	0.2	42.3	16.5	41.8	4.3	41.0	4.5
R69-G	0.94	0.04	1.02	0.01	0.97	0.11	2.9	1.0	2.3	0.4	4.2	1.0	53.3	15.3	35.8	5.6	62.0	13.7
R56-F	0.94	0.09	1.02	0.05	0.84	0.09	4.3	0.5	3.6	0.3	1.7	0.7	70.7	10.0	68.0	4.9	41.4	15.5
R62-F	0.90	0.02	0.89	0.16	0.90	0.07	1.1	0.2	0.9	0.3	1.5	1.0	28.0	12.4	18.0	5.9	20.8	11.8
R69-F	0.97	0.12	0.97	0.03	0.91	0.03	2.9	1.5	3.5	0.7	2.8	1.2	55.8	28.6	79.8	11.1	63.6	22.5
15-30 cm																		
R56-G	1.15	0.06					1.5	0.3					42.4	20.7				
R62-G	1.29	0.01	1.29	0.02	1.31	0.06	2.4	0.8	2.8	0.8	3.9	0.6	51.8	18.0	61.5	4.3	75.4	0.8
R69-G	1.21	0.07	1.21	0.05	1.14	0.18	1.4	0.3	1.5	1.1	2.0	1.3	49.0	27.7	57.9	37.7	44.0	29.4
R56-F	1.02	0.03	0.95	0.04	1.02	0.09	1.4	0.3	1.5	0.7	1.1	0.4	37.9	10.5	43.7	3.8	48.3	11.0
R62-F	1.11	0.21	1.03	0.05	1.02	0.13	0.9	0.4	0.6	0.3	0.7	0.2	31.1	10.5	13.6	2.6	10.1	8.3
R69-F	1.21	0.20	1.19	0.05	1.13	0.05	1.3	0.4	1.2	0.3	1.5	0.7	31.9	6.0	41.8	5.8	60.7	10.9

R56-G is site reclaimed in 1956 under grass cover, R62-G- reclaimed in 1962 under grass cover, R69-G- reclaimed in 1969 under grass cover, R56-F reclaimed in 1956 under forest cover, R62-F reclaimed in 1962 under forest cover, and R69-F- reclaimed in 1969 under forest cover

Table 3. Mean and standard deviations of soil pH and electrical conductivity (EC) at different slope positions (U-upper, M is middle, and L is lower slope)

Sites	pH						EC (dS/m)					
	U		M		L		U		M		L	
	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
						0-15 cm						
R56-G	7.66	0.20					0.66	0.12				
R62-G	7.92	0.04	8.00	0.09	7.98	0.07	0.25	0.01	0.26	0.01	0.31	0.04
R69-G	8.33	0.17	8.14	0.19	7.33	1.45	0.24	0.03	0.39	0.30	0.25	0.09
R56-F	7.95	0.18	7.92	0.09	7.78	0.04	0.45	0.15	0.43	0.03	0.45	0.06
R62-F	7.58	0.91	8.09	0.09	8.04	0.19	0.15	0.12	0.21	0.06	0.20	0.03
R69-F	8.23	0.09	8.18	0.03	7.47	1.40	0.25	0.06	0.26	0.01	0.20	0.06
						15-30 cm						
R56-G	7.89	0.24					0.36	0.00				
R62-G	8.19	0.08	8.29	0.08	8.20	0.06	0.16	0.13	0.16	0.13	0.26	0.04
R69-G	8.27	0.23	7.21	0.74	6.68	2.03	0.30	0.48	0.10	0.14	0.18	0.16
R56-F	8.05	0.10	8.07	0.06	8.08	0.02	0.32	0.05	0.31	0.04	0.29	0.02
R62-F	8.39	0.08	8.30	0.10	8.08	0.23	0.11	0.08	0.09	0.13	0.14	0.10
R69-F	8.29	0.23	8.31	0.09	6.63	2.14	0.11	0.16	0.22	0.03	0.24	0.19

R56-G is site reclaimed in 1956 under grass cover, R62-G- reclaimed in 1962 under grass cover, R69-G- reclaimed in 1969 under grass cover, R56-F reclaimed in 1956 under forest cover, R62-F reclaimed in 1962 under forest cover, and R69-F- reclaimed in 1969 under forest cover

Table 4. The Bonferroni multiple comparisons (BSD) values for mean separation for different interactions

Location	Sand	Silt	Clay	BD	TN	SOC	pH	EC
1. Slope positions within a location (position x sample)								
			0 - 15 cm					
R62-G	NS	NS	NS	NS	1.41	NS	NS	0.06
R69-G	3.98	4.98	NS	NS	1.87	NS	NS	NS
R56-F	NS	NS	NS	NS	0.93	26.2	NS	NS
R62-F	NS	NS	NS	NS	NS	NS	NS	NS
R69-F	NS	NS	NS	NS	NS	NS	NS	NS
			15 -30 cm					
R62-G	NS	NS	NS	NS	NS	NS	NS	NS
R69-G	NS	NS	NS	NS	NS	NS	NS	NS
R56-F	7.93	6.86	2.72	NS	NS	NS	NS	NS
R62-F	NS	NS	NS	NS	NS	17.2	0.22	NS
R69-F	NS	NS	NS	NS	NS	20.3	NS	NS
2. Location x sample at each slope position with in continuous grass cover sites								
			0-15 cm					
Upper	4.8	7.0	4.0	0.04	NS	NS	0.0	0.0
Middle	NS	1.46	NS	NS	NS	NS	NS	NS
Lower	NS	2.48	NS	0.06	2.96	NS	NS	NS
			15 -30 cm					
Upper	9	8.41	NS	0.13	NS	NS	NS	NS
Middle	NS	NS	NS	NS	NS	NS	NS	NS
Lower	NS	NS	NS	NS	NS	NS	NS	NS
3. Location x sample at each slope position with in continuous forest cover sites								
			0-15 cm depth					
Upper	20.1	13.34	NS	NS	2.06	NS	NS	0.12
Middle	31.1	21.80	NS	NS	1.13	20.37	0.18	0.07
Lower	15.9	10.54	5.53	NS	NS	NS	NS	0.14
			15 - 30 cm depth					
Upper	NS	NS	NS	NS	NS	0.33	0.19	NS
Middle	11.8	6.97	5.02	0.05	NS	4.32	0.22	0.18
Lower	17.1	13.22	NS	NS	NS	24.32	NS	NS
4.Stochastic Location x sample at each slope position among all sites								
			0 - 15 cm					
Upper	10.5	7.9	6.4	0.1	1.29	27.29	NS	0.1
Middle	19.96	13.61	7.12	0.17	0.81	13.74	0.21	NS
Lower	12.79	8.52	4.49	0.16	1.8	29.04	NS	0.12
			15 - 30 cm					
Upper	NS	NS	NS	0.19	0.87	NS	0.32	NS
Middle	15.23	8.36	NS	0.09	1.17	30.94	0.66	0.15
Lower	13.41	10.36	NS	0.23	1.27	31.67	NS	NS